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GB 2241004 A EP 0411560 A

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(54) Soil consolidation

(57) Soil consolidation using an injection tube (2) having mixing blades (3) at the lower end thereof is characterised by the injection into the soil of a granular material, eg sand or gravel, and a consolidating agent. The granular material is injected during the penetration phase of the injection tube (2) and the consolidating agents are injected during the extraction of the injection tube.

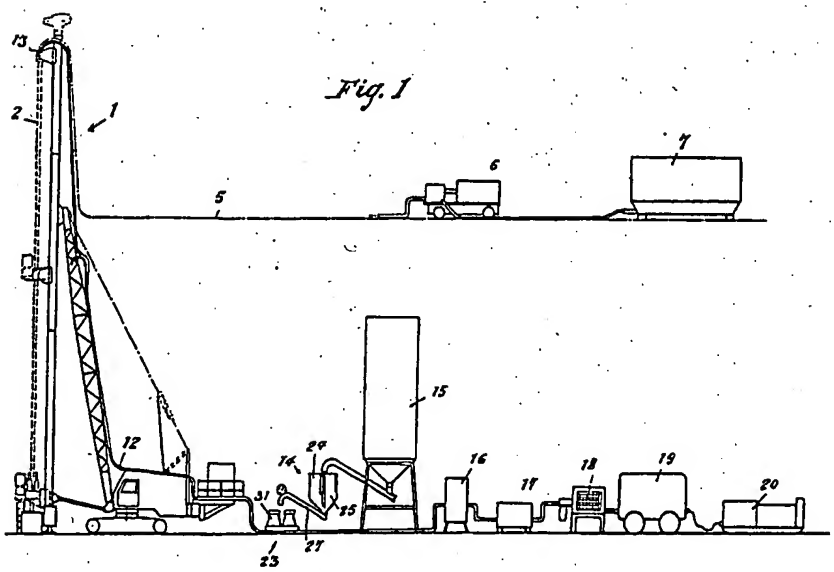

Fig. 1

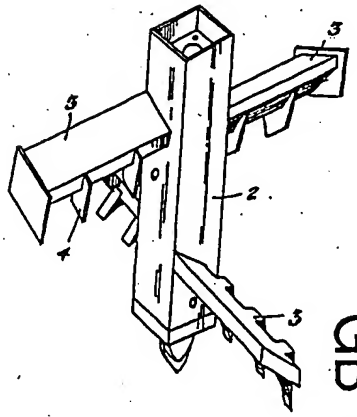

Fig. 5

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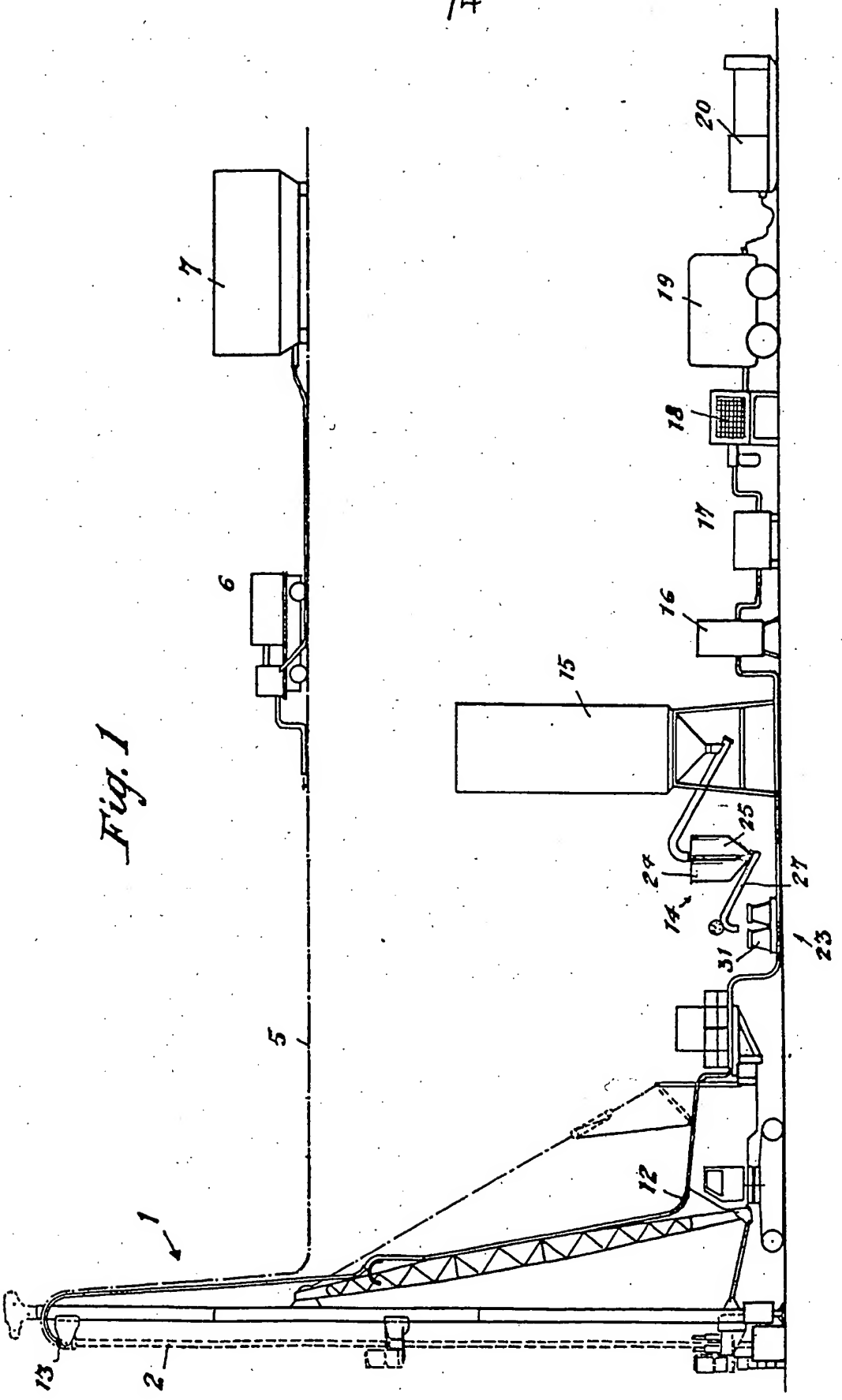


Fig. 1

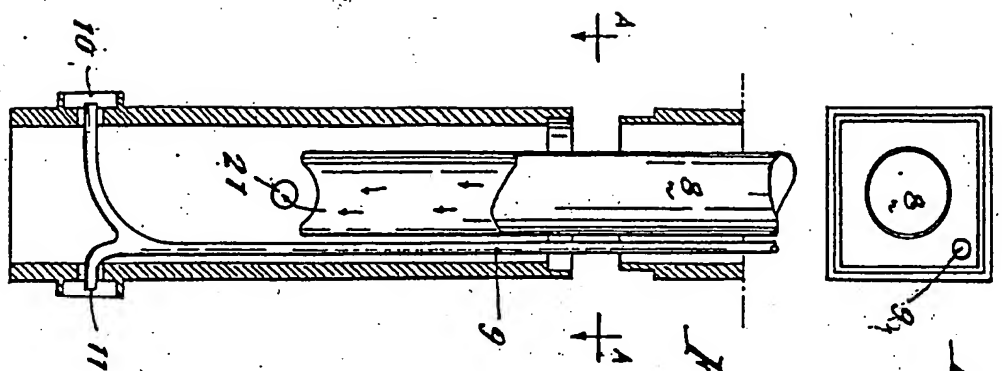


Fig. 2

Fig. 3

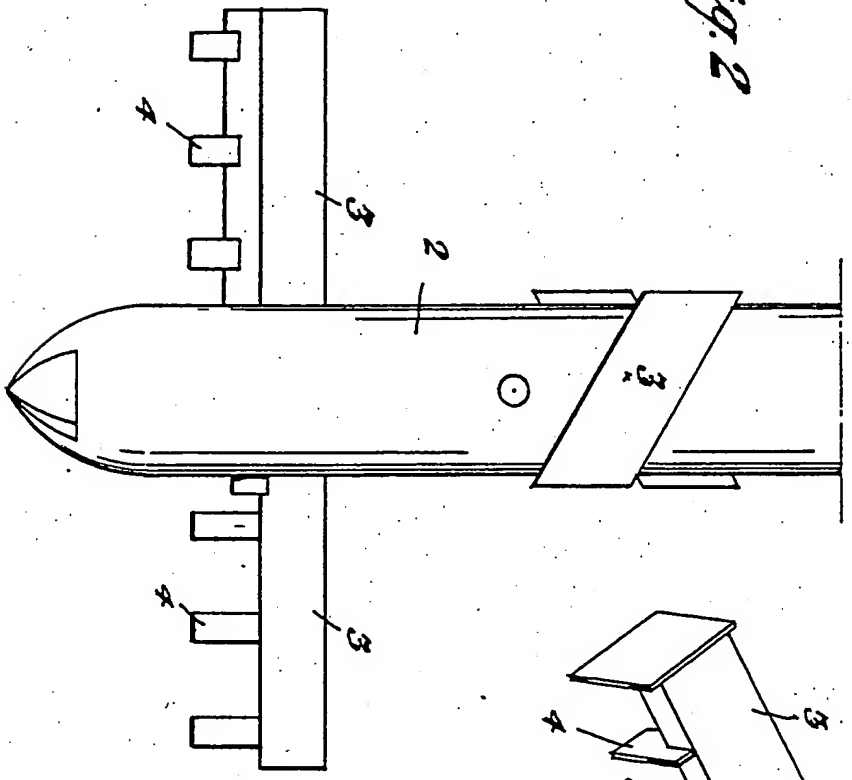


Fig. 4

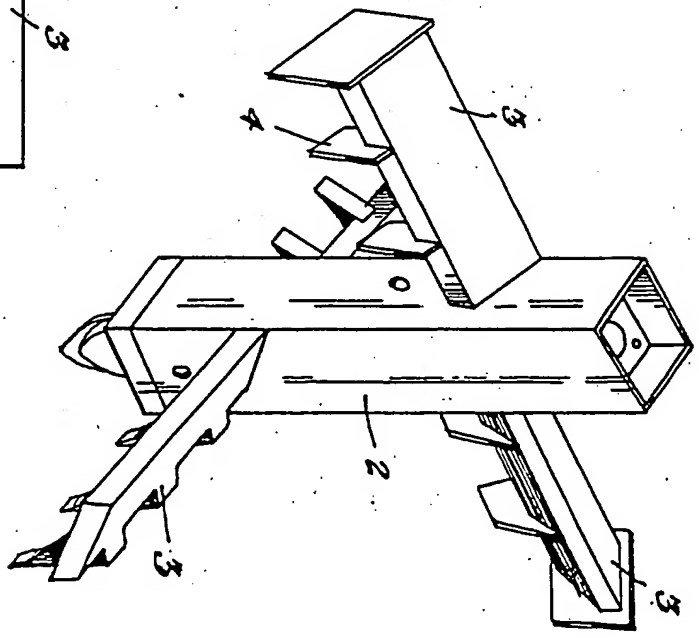


Fig. 5

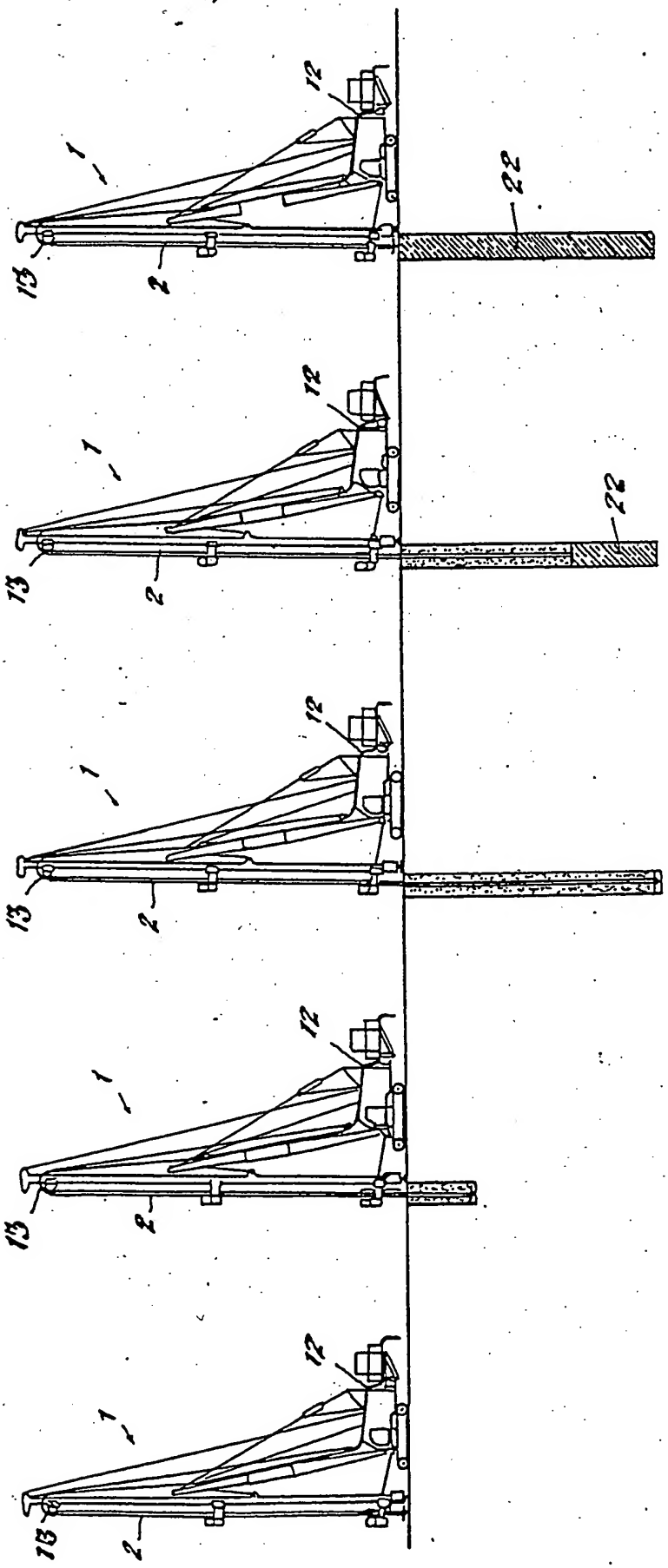


Fig. 6

Fig. 7

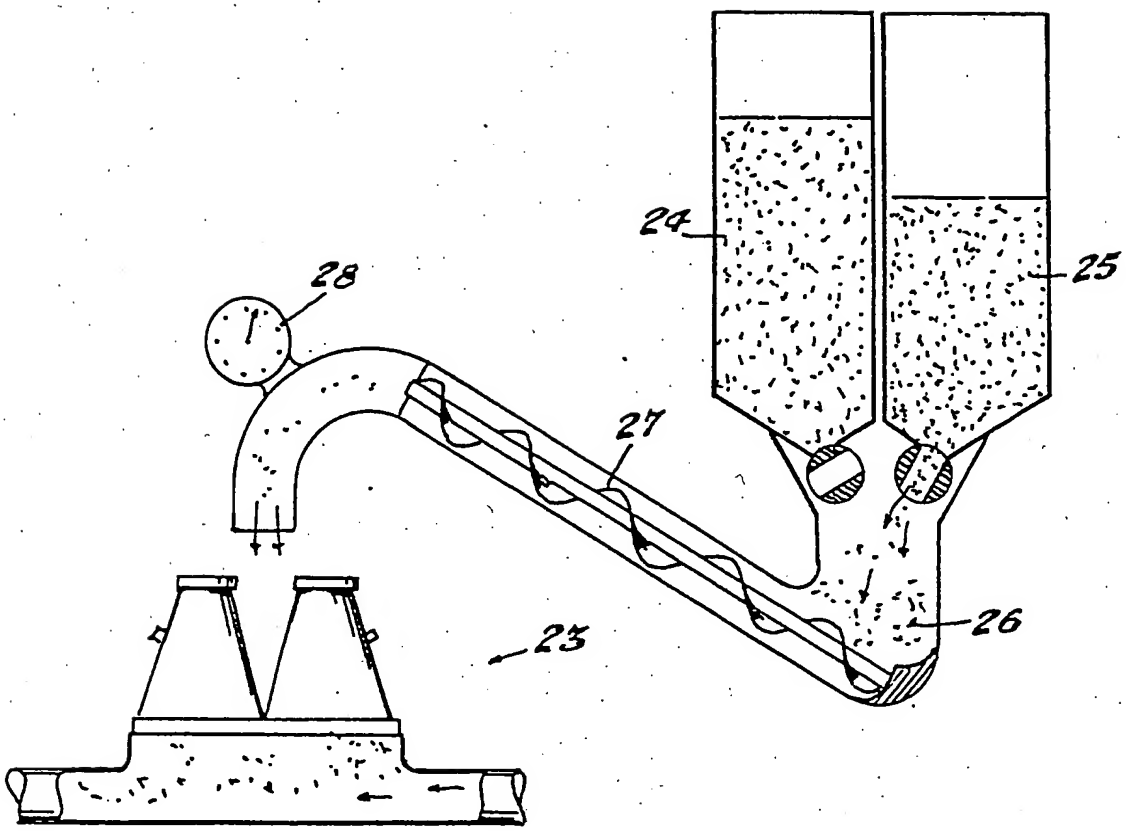
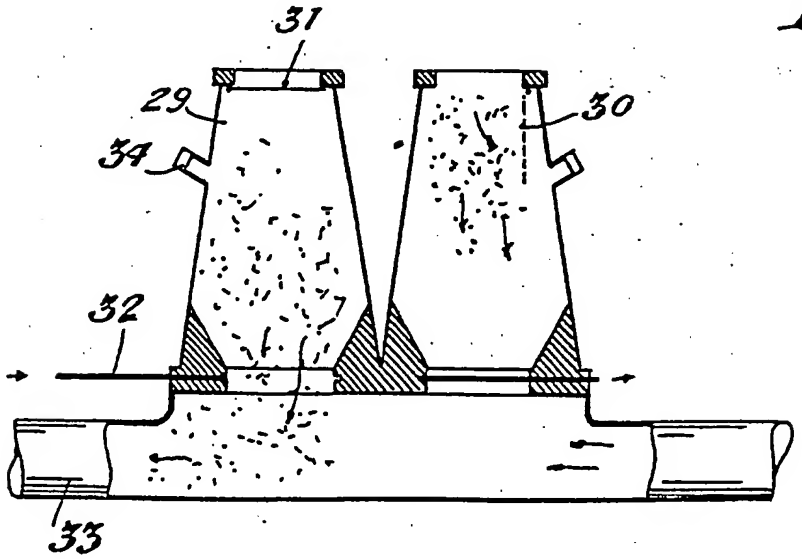


Fig. 8



METHOD AND APPARATUS FOR CONSOLIDATING COLUMNS OF TERRAIN

The present invention deals with a method for obtaining consolidated columns of terrain and apparatus which goes to make up such a system.

In the field of consolidation and deep stabilisation of unstable terrains (for example silt, sand, clay, peat, lignites, etc.) the technique of mixing chemical agents, such as calcium and cement with the terrain so as to obtain an improvement in the mechanical characteristics of the terrain itself is well established.

Such techniques were known to the Romans and Chinese who used to stabilise and consolidate silt clays with lime mixtures.

At the present, there are numerous studies and applications of these systems in Holland, France, Japan and Italy.

The technology used at the moment envisages the creation of deep consolidated columns by way of the following phases:

1 - Breaking up of the terrain mechanically by inserting a rotating blade or shovel disintegrator-mixer in the terrain, dry for inconsistent loose terrain or with the aid of water to facilitate the penetration of the breaking tool into soft consistent terrains.
In some applications this breaking up is obtained using water, by injecting fluid (water) at very high speed and pressure.

2 - The immission of stabilising chemical agents into the terrain and their mixing with the terrain.

The applications used have been realised with the use of various technologies such as:

a) the forced introduction of the dry chemical agent during the extraction of the breaking up-mixer tool when the direction of rotation is reversed (Swedish L-C-M- method),

cfr. : ATTI dell'ISTITUTO DI SCIENZA DELLE COSTRUZIONI - Politecnico di Torino, Ing. Marco Bertero, Paolo Marcellino "DEEP STABILISATION" November 1981, no.5, p.20.

b) the introduction of the dry chemical agent via a pipe located on the lower end of the breaking up-mixer tool situated at the top of the breaking up-mixer device of a screw conveyer for feeding and distributing the agent in the terrain and at the same time extracting the tool by reversing the direction of rotation (Japanese method D-L-M); (Publication cited above) p.21.

c) Introduction of the chemical agent in a fluid state (water-cement mixture) via a pipe whose lower end is located at the top of the breaking up-mixer tool using a methodology similar to that of the system described above in point b) (Japanese method C-M-C) (Publication cited above) p.22.

d) Introduction of the chemical agent in a fluid state (water cement mixture) via a pipe inserted along the axis of the breaking up-mixer device whose outlet is located where the blade or shovel is using a methodology similar to the systems described above in points b) and c) (Japanese method D.M.C.) (Publication

cited above) p.23.

e) Introduction of the chemical agent in a fluid state (water cement mixture) via a hollow shaft located at the lower end of the breaking up-mixer tool. The introduction of the mixture takes place, during the tool's insertion and penetration into the terrain, by means of pressure injection via lateral and bottom end outlets located where the tool is. The tool is then extracted by reversing the direction of rotation (Italian method - ELSE) (Publication cited above, p.23).

The mixing techniques detailed above, that is to say the introduction into the terrain using dry (lime-cement) powdery systems or using humid cement stream systems have the drawback that where the terrain is characterised by lack of structure, a considerable content of organic elements or excess of sulphates, or in any case has a considerable level of porosity, the process of hydration of the binding material can be considerably delayed or even totally inefficient.

To overcome this drawback, it has been suggested that additives such as monogranmular silicon sands, calcium or chloride carbonates or others, either granular or filiform but not powdery, could be used to ensure the effectiveness of the treatment of the terrain. The advantages of the present invention derive from the introduction of the above-mentioned additives by means of the forced immission of granular or filiform materials so as to form an inert structure in the treated terrain which thus displays enhanced mechanical characteristics;

The invention will be expounded in greater detail below with the aid of the attached figures which shows it being carried out. In these figures:

Figure 1 represents, in diagram form, the entire working unit for consolidating terrain in general; Figure 2 shows a partial section of the terrain penetration rod;

Figure 3 is a section along the axis A-A;

Figure 4 shows the end of the penetration rod in the terrain while removing it;

Figure 5 gives an axiometric view of Figure 4;

Figure 6 shows the following phases of the work;

Figure 7 shows the function of the propulsors in diagram form;

Figure 8 shows a detail of the propulsors with the alternate valve clearance.

Figure 1 shows (1) the mechanical arm which enables the rotation and penetration of the rod (2) for breaking and crumbling the earth. The mechanical action of breaking and crumbling the terrain is obtained by inserting into the terrain a tool (3) which is securely attached to the lower end of the penetration rod (2). This tool (3) comprises two or more cutting blades (4). The tool is inserted into the terrain by means of a rotating thrust in a clockwise direction either dry or with the circulation of fluids introduced via the tube (5) with the pump (6) which collects the liquid from the container (7). The liquids are released only when the nature of the terrain is such as to require them.

The dimensions of the tool's blade determine the diameter of the column to be created and the shape and inclination appropriate to both the insertion in the terrain at the necessary forward speed and also for the breaking up and mixing of the terrain. The hollow rod (2) can have either a polygonal or cylindrical section and is fitted inside with tubular pipes, the central one (8) for transferring the consolidating liquids and the neighbouring one (9) for letting the liquids which are to moisten the terrain surrounding the penetration rod pass. The liquids exit from tube (9) at points (10) and (11) in a radial manner. When the terrain has been mechanically broken up by the rod (2), thanks to the forced immision of sand or gravel, the rod begins to return to the surface and during this anti-clockwise motion forcefully introduces cement from tube (12), which is joined to the central tube (8) of the hollow rod (2) at point (13).

The immission system equipment comprises a feeder (14), silos of cement and inert material (15), a air bell (16), a dryer (17), a cooling unit (18) and a compressor (19) needed for the thrust of the propulsors (23) of the materials and a generator (20). The consolidating materials exit via one or more outlets (21).

According to the stratification of the terrain, the operator uses tube (9) to let in the fluid needed for moistening the terrain and the consolidating materials.

The consolidating material and any eventual fluid are forcefuly channelled into the terrain by way of the outlets which are positioned in such a manner that said materials are distributed

in a radial and uniform manner to ensure the terrain is condolidated in a compact and homogeneous manner. The consolidation is considered terminated when the penetration rod is out of the terrain, thus forming a column of consolidated terrain (22). The system of consolidating the terrain is based on the immission of sand or gravel in the penetration phase in a clockwise direction and the immission of cement when the penetration rod is being extracted in an anti-clockwise motion. Hence the entire system of propulsion is composed of two silos, one for sand or gravel and the other for cement. The material is supplied alternately from the silos (24-25) to the chamber (26) to the screw conveyor intake (27) where the feeder (28) transmits the quantities of cement and sand or gravel which are supplied to the propulsors (29-30). These propulsors have an upper valve (31) which opens downwards under the weight of the material which enters it and below a disc or guillotine valve (32) which is controlled by either an electrical or mechanical system. The valves function alternately; when the first propulsor is full of material the top valve (31) closes, the bottom valve (32) opens and the material falls into the tube (33) where the compressed air forces it into the terrain which is to be consolidated via the hollow rod (2). A valve (34) acts as a decompressor for each propulsor. The binding mixture mixed with the already broken up terrain forms a homogeneous paste, the hydrating actions being guaranteed by the water which is naturally contained in the terrain or which has been introduced when inserting the tool to break up the earth as described above.

CLAIMS

1. Apparatus for consolidating columns of terrain by way of the forced immission of inert materials, which may be granular, mainly sand or gravel and dry consolidating agents, including a penetration rod which has inside it tubes for the forced immission of the consolidation binder and a tube for the forced immission of fluids and an integral tool at the lower extremity of the rod equipped with cutting blades whose purpose is to remove and break up the terrain anbd produce a hole with a diameter equal to the width of the tool which is characterised by the fact that the tubes inside the rod forcibly inject into the terrain by means of the propulsors granular material, mainly sand or gravel, and consolidating agents and fluids according to the nature of the terrain.

2. Apparatus as claimed in claim 1 characterised in that the rod which penetrates the terrain has a polygonal section.

3. Apparatus as claimed in claim 1 characterised in that the rod which penetrates the terrain has a circular section.

4. Apparatus as claimed in claims 1, 2 or 3 characterised in that the blades of the cutting tool have a slight inclination with respect to the horizontal plane.

5. Apparatus as claimed in any preceding claim characterised in that the outlets which channel the consolidating material and the fluids are arranged radially so as to obtain an optimal amalgramation of the consolidating materials and the terrain.

6. Apparatus as claimed in any preceding claim characterised in that the completion and consolidation of the column of terrain take place while the penetration rod is being retracted from the terrain.

7. A method for consolidating column of terrain characterised by the steps of

storage in leakproof silos of the granular and/or filiform materials and the binding powdery materials;

transport of the above-mentioned materials of the predetermined quantitiy of the material necessary for obtaining a consolidated column by means of separate screw conveyors to the feeding hopper equipped with scales and equipment for reading and recording the load and doses of the granular and powdery materials;

transport and immission by means of screw conveyors of the insert granular materials and consolidating agents in pressure propulsors of a cylindrical or upturned semiconical form equipped with leakproof upper and lower valves operated electro-pneumatically and with decompression valves inside the propulsor at the moment of unloading the materials;

transport of the above mentioned materials via tubing up to the outlet holes which are located at the same point as the breaking up and mixing tool by means of compressed air which, for this specific purpose, has been cooled and made dry.

8. Apparatus for consolidating columns of terrain substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

9. Method for consolidating columns of terrain substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number: 9201721.9

Relevant Technical fields

(i) UK Cl (Edition K) E1F (FPC); E1H (HGJ

(ii) Int Cl (Edition 5) E02D

Search Examiner: D B PEPPER

Databases (see over)

(i) UK Patent Office

(ii)

Date of Search: 3 MARCH 1992

Documents considered relevant following a search in respect of claims 1 TO 9

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X,P	GB 2241004 A MITUO HARA Whole document	1 and 7 at least
A	EP 0411560 A TREVI SPA Whole document	1 and 7

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Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

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